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Inclusive Puzzle Design as an Innovative STEM-Based Learning Tool for Children with Special Needs

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Abstract
Inclusive education requires adaptive and accessible learning media to accommodate the diverse abilities of children with special needs, especially in the context of STEM (Science, Technology, Engineering, and Mathematics) learning. This study aims to develop and evaluate inclusive STEM puzzles as innovative learning tools to support the cognitive, motor, and emotional development of children with special needs. A quantitative quasi-experimental design combined with a Research and Development (R&D) approach was used. The inclusive puzzle, D-PUZZLO, was developed using the ADDIE framework and implemented with 16 children at a Special School in Temanggung, Central Java, Indonesia. The study lasted for 1 month, with each child receiving 5 consecutive sessions, each lasting 30 minutes. Pre-test and post-test evaluations were conducted. Analysis used the Wilcoxon Signed Rank Test. Results showed a statistically significant improvement in puzzle completion performance, independence, assembly speed, fine motor skills, emotional engagement, and visual discrimination related to shape and color design ($p < 0.01$). High-contrast colors, gradual difficulty levels, and adjustable puzzle shapes increased task engagement and efficiency. These findings indicate that inclusive puzzle design based on STEM principles and Gestalt theory effectively promotes learning through practice, motivation, and self-directed learning. Inclusive STEM-based puzzles provide a practical and adaptable solution for equitable learning experiences for children with special needs

Keyword : Inclusive Puzzle; Design; STEM; Children Special Needs

Introduction

Inclusive education aims to ensure equal learning opportunities for all children, including children with special needs, by providing learning environments and instructional media that are responsive to diverse abilities and learning characteristics. Recent developments in inclusive education emphasize not only physical and social accessibility but also the use of adaptive, creative, and accessible learning media, particularly within STEM education (Science, Technology, Engineering, and Mathematics) contexts(Monteira, 2025). In STEM learning, children

especially in early childhood and primary education develop knowledge and skills through exploration, object manipulation, and problem-solving activities. Educational games such as puzzles offer a multisensory learning environment that integrates cognitive processing, fine motor skills, and critical thinking, which are fundamental components of STEM-based learning. Previous studies indicate that play-based and creative STEM approaches effectively stimulate intuitive thinking, collaboration, and early problem-solving skills(Monteira, 2025).

Recent research on inclusive game-based educational solutions for learners with visual impairments highlights the importance of inclusive play-based tools that address sensory needs and meaningful learning experiences. Tactile and audio-based educational games have been shown to enhance engagement and conceptual understanding in STEM learning compared to conventional instructional methods (Castaneda et al., 2025). Furthermore, studies on puzzle-based learning for children with special needs demonstrate that puzzles not only improve cognitive skills and concentration but also serve as engaging and meaningful learning media. Puzzle activities support logical reasoning, attention, and analytical skills through direct hands-on experiences in pattern recognition and problem-solving(Sulistia, Ermawati, Fadhila, Zidan, & Siti, 2022). However, the integration of inclusive design principles within STEM-oriented puzzle learning remains limited. Integrating inclusive educational design principles into STEM-based learning media is therefore crucial. Such integration not only expands access to learning but also strengthens self confidence, motivation, and emotional engagement, which are particularly important for children with special needs(Bustamante-mora, Diéguez-rebolledo, Díaz-arancibia, Sánchez-vázquez, & Medina-gómez, 2025).

Despite the growing interest in STEM education and inclusive learning media, several research gaps remain. Most existing STEM studies focus on typically developing children, with limited research integrating STEM principles into inclusive learning media for children with special needs. Educational puzzles are generally used as generic learning tools rather than as structured STEM-based media designed for inclusivity(Bustamante-mora et al., 2025). Furthermore, prior studies emphasize learning outcomes while giving insufficient attention to inclusive design characteristics, such as sensory adaptation, graduated difficulty levels, and flexibility to accommodate diverse special needs. In addition, emotional engagement, motivation, and affective responses in inclusive STEM-based puzzle learning remain underexplored, as previous research has largely focused on cognitive outcomes. This study addresses existing gaps by developing and evaluating an inclusive STEM-based puzzle for children with special needs. It aims to examine the effectiveness of inclusive puzzle design adapted to sensory, cognitive, and motor characteristics, and to assess its impact on learning engagement, motor skills, independence, emotional responses, and task completion speed.

Theoretical Review

Inclusive Education

Inclusive education emphasizes equitable access to learning by recognizing diversity in abilities, learning styles, and special needs. Learning media should therefore be flexible, accessible, multisensory, and adaptive. STEM learning integrates Science for observation and exploration, technology learning tools and media,

engineering by designing and constructing, mathematics include patterns, shapes, and logical reasoning. Play based STEM learning has been shown to enhance problem solving skills, critical thinking, and learning engagement.

Inclusive Puzzle Design

Inclusive puzzles are designed by considering: safe size and shape, sensory-friendly colors and textures, progressive difficulty levels, flexibility for various special needs. Puzzles function as concrete manipulative media, enabling learning through direct experience (*learning by doing*).

Methods

Research design quntitatif using quasy experimental desaign, and adopts a research and development (R&D) approach to develop and evaluate an inclusive puzzle as a STEM-based learning, with ADDIE framework (Analysis, Design, Development, Implementation, Evaluation), both commonly used in inclusive educational media development(Ade, 2025). To evaluate the effectiveness of the developed product, a quasi-experimental design using a one-group pre-test and post-test approach was employed during the implementation phase(Fadhil, Masyitah, & Mahmudi, 2025). Research procedure needs analysis and contextual review, inclusive puzzle design based on STEM principles, prototype development and expert validation, pilot testing with children with special needs, effectiveness evaluation, revision and dissemination. Data collection techniques was conducted for 1 month, in July-August 2025, each child received 5 day, each times meetings 30 minutes, evaluations were carried out using pre-tests and post-tests. The research was conducted at extraordinary school Temanggung, Central Java, Indonesia. Data Analysis using non-parametric tests Wilcoxon Sign Rank Test.

Results and Discussions

Puzzlo Research and Development STEM-Based Learning Tool

The inclusive STEM-based puzzle was successfully developed through the Research and Development (R&D) process using the ADDIE frameworks(Pratama, Annisa, Teknik, Nahdlatul, & Sumatera, 2025). The final product consisted of a multisensory puzzle incorporating STEM elements such as pattern recognition, logical sequencing, simple engineering construction, and problem-solving tasks. The first stage of this research and development activity was an initial investigation(Hamidaturrohmah, Muh, Aniatus, & Nailufar Daniela Arnesti Nailufar, 2023) conducted through needs analysis and problem identification among children with special needs at SLB C, Temanggung district. The second stage was the design phase, which was conducted after the initial data had been obtained. This phase aimed to enhance cognitive and psychomotor abilities through puzzle play.

The puzzle is named D-PUZZLO, made from thick cardboard and covered with illustrated paper, measuring 21 × 30 cm. It has a firm texture and is easy to assemble and disassemble. The largest puzzle pieces measure full angular shape 8.5 × 9 cm, while the other pieces are corner-shaped, measuring 5.5 × 10 cm and 11 × 8 cm. The puzzle features a variety of images, including vegetables, fruits, school supplies, transportation tools, bathing equipment, air balloons, airplanes, and other everyday items. The primary purpose of this puzzle is to enhance children's understanding of

daily needs, including nutrition, school activities, and modes of transportation. The puzzle shapes are designed in three models: fully angular shapes, angular shapes combined with one curved shape, and angular shapes combined with three curved shapes.

The third stage involved development of a STEAM-based product in accordance with the previously designed framework. Overall, the inclusive puzzle was rated as highly feasible in terms of accessibility and safety, alignment with STEM learning principles, suitability for children with special needs, clarity of instructions and usability. Experts highlighted the strengths of the puzzle in its sensory-friendly design, progressive difficulty levels, and adaptability for different learning abilities. Minor revisions were recommended, primarily related to color contrast optimization and instructional simplification.

Picture 1. D-Puzzlo Shape(Harel, Itzhak, & Ohad, 2024)

The puzzle is classified according to the number of pieces to indicate difficulty levels: easy (6 pieces), moderate (9 pieces), and difficult (15 pieces). Color combinations are classified into three categories, namely high contrast, moderate contrast, and low contrast.

6 Pieces **9 Pieces** **15 Pieces**

Figure 1. D-Puzzlo Pieces

The fourth stage involved the implementation of the D-Puzzlo puzzle design for children with special needs in accordance with the established criteria. The inclusive puzzle was implemented in a small-group learning setting involving children with special needs in an inclusive or special education context. During the implementation phase, children actively engaged in puzzle-based STEM activities that required object manipulation, pattern construction, and basic problem-solving. Observational data indicated that most participants were able to follow the learning activities with minimal assistance after initial guidance. The puzzle facilitated learning by doing,

allowing children to explore STEM concepts through hands-on interaction rather than abstract instruction.

The fifth stage involved the evaluation of the puzzle Learning Outcomes. Results from participatory observations and engagement rating scales showed an increase in learning engagement during puzzle-based STEM activities. Children demonstrated level of independence, speed of compilation, Joyful response and fine motor skills. Positive emotional engagement appeared to contribute to sustained participation and willingness to attempt more challenging puzzle levels.

D-Puzzlo Intervention Outcomes

The study involved 16 children with special needs who participated in the implementation of the inclusive STEM-based puzzle learning activities. All participants completed the intervention sessions and were included in the data analysis. Sample Size Total participants 16, relatively small sample, so percentages can change significantly with small changes in numbers. Distribution by gender male 13 children and female 3 children, average age 10-11years old, equivalent to elementary school level. The research procedure followed ethical considerations, ensuring confidentiality and informed consent from the school and guardians of the participants, adhering to ethical research guidelines for studies involving children with disabilities.

Table 1. Responden Distribution

JK (Gender)	Frequency	Percent	Valid Percent	Cumulative Percent
Male	13	81.3%	81.3%	81.3%
Female	3	18.8%	18.8%	100.0%
Total	16	100.0%	100.0%	–

Dataset of 16 items/participants, the majority (62.5%) fall into the moderate complexity category, while high and low complexity are equally small (18.8% each). The distribution is heavily centered on moderate complexity, which may influence analysis outcomes.

Number of Puzzle Pieces Completed

The inclusive puzzle was designed in three levels of complexity based on the number of pieces 6 pieces (low complexity), 9 pieces (moderate complexity), 15 pieces (high complexity). The puzzles were developed with large-sized pieces to support ease of manipulation, safety, and fine motor coordination. The progressive increase in the number of pieces was intended to accommodate varying levels of cognitive and motor abilities among children with special needs.

A Wilcoxon signed-rank test was conducted to compare pre-test and post-test performance in the number of puzzle pieces completed. The results showed a statistically significant increase following the intervention (Z: –3.358, p: 0.001), indicating that the inclusive puzzle design effectively enhanced task performance. A total of 13 participants showed improvement, while 3 participants showed no change, and no participants demonstrated a decline. Interpretation that the inclusive puzzle design effectively enhanced children's cognitive engagement and problem-solving capacity.

Level of Independence

All participants (100%) demonstrated improved independence in completing the puzzle tasks after the intervention. The Wilcoxon signed-rank test confirmed a highly significant improvement ($Z = -4.00$, $p < 0.001$). These findings indicate that the D-PUZZLO intervention was highly effective in enhancing autonomous task performance, problem-solving ability, and self-directed learning among children with special needs. The structured variation in puzzle difficulty, shape, and color contrast contributed to increased engagement and independence during task completion. All participants (100%) demonstrated improved independence in completing the puzzle tasks after the intervention. The Wilcoxon test confirmed a highly significant improvement ($Z = -4.00$, $p < 0.001$). The Puzzel intervention strongly promoted autonomous task performance among children with Special Needs.

Puzzle Assembly Speed

The analysis revealed a significant improvement in puzzle assembly speed following the intervention ($Z = -3.16$, $p = 0.002$). Ten participants demonstrated faster completion times, while six participants showed no change. No participants experienced a decline in performance. These findings suggest that the intervention effectively enhanced sustained attention, visual–motor integration, and fine motor coordination during puzzle assembly activities. The structured design of the D-PUZZLO, including graduated difficulty levels and varied shape configurations, likely supported improved efficiency and task focus among children with special needs. The analysis revealed a significant improvement in puzzle assembly speed following the intervention ($Z = -3.16$, $p = 0.002$). Ten participants showed faster completion times, while six participants exhibited no change. The results suggest enhanced focus and motor coordination during puzzle assembly activities.

Mood (Enjoyment Level)

All participants demonstrated an improvement in mood, transitioning from an 'unhappy' state during the pre-test to a 'happy' state in the post-test condition. The Wilcoxon signed-rank test indicated that this change was statistically significant ($Z: -4.00$, $p < 0.001$). These findings suggest that the inclusive puzzle activity fostered a positive and supportive learning environment, enhancing enjoyment, intrinsic motivation, and emotional engagement during the learning process. The use of varied colors, shapes, and achievable challenge levels likely contributed to increased positive affect and sustained participation among children with special needs. All participants experienced an improvement in mood, transitioning from *not happy* during the pre-test to *happy* in the post-test condition. This improvement was statistically significant ($Z:-4.00$, $p < 0.001$). The inclusive puzzle activity created a positive emotional learning environment, increasing enjoyment and motivation.

Fine Motor Skills

Observational assessments indicated an improvement in fine motor skills among participants after engaging with the inclusive puzzle activities. Children demonstrated better hand–eye coordination, more controlled grasping, and smoother piece placement during puzzle completion compared to initial observations. Improvements were most noticeable when children interacted with puzzles containing 6 and 9 pieces,

suggesting that lower to moderate puzzle complexity was more suitable for supporting fine motor development. The Wilcoxon test demonstrated a significant improvement in fine motor skills after the intervention (Z:−3.82, p < 0.001). All participants showed progress from a *low* to an *improved* motor skill level. Interpretation: The manipulation of puzzle pieces provided effective fine motor stimulation for children with down syndrome.

Puzzle Shape Design

Participant showed a increase, most participants improved from full angular shape to angular shape plus one curved and three curved. This indicates that the change largely positive. Magnitude of Change (Mean Rank & Sum of Ranks) Mean Rank for positive ranks 7.50 Average rank of participants showing improvement. Sum of Ranks : 105 Total positive rank sum, reflecting the collective improvement. Since there are no negative ranks and most are positive, this strongly suggests a statistically significant improvement. While regular shaped puzzle pieces appeared easier to handle descriptively, shape variation alone did not significantly influence performance outcomes. Statistics table presents the results of the Wilcoxon Signed Ranks Test comparing Shape 2 and Shape 1. The Z value of −3.494 with an Asymp. Sig. (2-tailed) of 0.000 (p < 0.001) indicates a statistically significant difference in performance between Shape 1, 2 and 3. The note 'based on negative ranks' indicates that the Z value was calculated based on negative rank differences, reflecting cases in which performance scores for Shape 2 were lower than those for Shape 1. Accordingly, these results suggest that Shape 1 produced better performance outcomes than Shape 2, and that this difference is unlikely to have occurred by chance.

Puzzle Color Design

Puzzle color demonstrated a statistically significant effect on performance (Z: −3.49, p < 0.001). Fourteen participants exhibited better performance when using high-contrast colors compared to uniform color designs, while the remaining participants showed no decline in performance. These findings indicate that high-contrast color combinations facilitated clearer visual discrimination, improved figure–ground perception, and increased task engagement during puzzle activities. The enhanced visual salience of high-contrast colors likely supported more efficient information processing and sustained attention, particularly among children with special needs. Puzzle color demonstrated a statistically significant effect on performance (Z:−3.49, p < 0.001). Fourteen participants showed better performance with high-contrast colors compared to uniform colors. High-contrast colors enhanced visual discrimination and task engagement.

Table 2. Puzzle Design Data Analysis Results

Parameter	Negative Rank	Positive rank	ties	Total	Positive Mean Rank	Positive Sum Rank	z	Asymp. Sig. (2-tailed)
Puzzle pieces	0	13	3	16	7	91	-3,358	0,0007
Level Of Independence	0	16	0	16	8,5	136	-4,000	0,000

Speed Of Compilation	0	10	6	16	5,5	55	-3,162	0,002
Joyfull	0	16	0	16	8,5	136	-4,000	0,000
fine motor skills	0	16	0	16	8,5	136	-3,819	0,000
Pazzel shape	0	14	2	16	7,5	105	-3,494	0,000
Pazzel Colour	0	14	2	16	7,5	105	-3,494	0,000

Discusion

This study examines puzzle shape design techniques and their application in children's learning. Puzzle games play an important role in the development of cognitive, sensory, and motor skills, as they require concentration and logical thinking, making them effective tools for stimulating learning and enhancing children's mental abilities. The study explores design concepts in terms of simplicity and complexity, as well as various types of traditional and digital puzzle games and their educational applications. It also focuses on structural design elements, such as illustrations, shapes, and typography, based on Gestalt theory, in the development of educational puzzle shapes. The effectiveness of these design elements in stimulating children's learning is evaluated. Gestalt theory is a psychological theory that explains how humans perceive and understand objects as a whole rather than as separate parts, emphasizing the principle that *the whole is greater than the sum of its parts*. In the context of puzzle design and children's learning, Gestalt theory helps explain how children naturally recognize shapes, patterns, and relationships between elements(Abdel, Fathi, & Mohammad, 2024). Visual perception is formed holistically; therefore, when learning through puzzle media, children tend to understand shapes as unified wholes rather than fragmented components. For children with special needs, puzzle media based on Gestalt principles can help improve cognitive abilities, visual perception, and concentration. Puzzles with alignable shapes and visual similarities encourage comparison, exploration, and meaningful interaction with parents or educators. Furthermore, this study analyzes puzzle design techniques and examines learning mechanisms and theories related to game-based learning(Abdel et al., 2024).

The STEAM (Science, Technology, Engineering, Art, and Mathematics) approach is an innovative educational strategy that integrates science, technology, engineering, art, and mathematics into the curriculum and learning process. STEAM learning is grounded in inquiry-based learning and requires the use of open-ended tools and materials (loose parts), which can enhance critical thinking skills among elementary school students. This approach is also considered effective in improving problem-solving skills in children with special needs. Science learning within the STEAM framework can increase learning motivation, particularly in addressing challenges, as supported research by Hwang and Taylor, which demonstrates that STEAM can facilitate learning for children with special needs(Hamidaturrohmah et al., 2023).

When young children have disabilities, learning methods must be adapted to their individual characteristics and abilities. However, little attention has been paid to the experiences of preschoolers with disabilities as they interact with geometric materials and concepts. Geometric features are closely linked to the shape of puzzles. Geometric concepts develop children's spatial thinking and foster independence(Yorde &

Mccollum, 2018). Research shows that more difficult puzzles tend to be more challenging for children. Similar shapes and manipulating the arrangement of shapes can increase the difficulty of puzzle play. When puzzles are played together with parents, this can enhance parental support for the child, thereby supporting the development of parent-child spatial language skills during puzzle play. A study by Sarah at 2022 revealed that the speed of puzzle play depends on the difficulty level of the puzzle shapes. In this study, puzzle play sessions were planned to end after 6 minutes; although there was some variability in the duration of play, the time spent did not differ significantly across puzzle types. However, there was variation in how many times children completed each puzzle, and the average time spent was higher for more difficult puzzles(Eason, Hurst, Kerr, Claessens, & Levine, 2022).

Puzzle media has great potential in stimulating the cognitive development of students with intellectual disabilities. A puzzle is an educational game medium that uses pieces of images, boxes, letters, and numbers designed to engage learners in assembling them quickly and accurately. Simple puzzles typically consist of two or three components that need to be reassembled into a cohesive whole(Munawwa, Yusuf, & Rejeki, 1999). Children with special needs are children who have different or greater needs than children in general, whether physical, intellectual, emotional, or related to the learning process. These conditions affect how they learn, interact with their environment, and participate in daily activities(Hamidaturrohmah et al., 2023).

Puzzle-based learning media can make the learning process more enjoyable and less monotonous. Students can learn while playing, making the classroom atmosphere livelier and more engaging(Munawwa et al., 1999). A child's mood affects puzzle therapy; if the child arrives in a cheerful state and appears happy and enthusiastic about completing the game(Biidnillah & Wahyuni, 2025). Puzzle is an educational game tool that has the benefit of improving memory for children with special needs. This aligns with previous research reporting that puzzle play therapy has an effect on short-term memory abilities in children(Biidnillah & Wahyuni, 2025).

Research of Tunggul et al in 2018 with title Puzzle Play Stimulation Affects Social Development and Independence in Preschool Children involved 17 participants and used the Wilcoxon test, obtaining a significant value of 0.000 (p-value < 0.05). The conclusion is that there is a significant effect of providing puzzle stimulation on social development and independence(Wahyuni, 2018). These results are similar to those of our study, even though puzzles were used to measure preschoolers' independence.

Education for children with special needs using puzzle-based media represents an innovative and effective approach to enhancing children's memory, concentration, logical thinking abilities, and fine motor skills. Number puzzles as instructional media provide not only visual and kinesthetic stimulation but also contribute to increased learning motivation. Drawing on Piaget's theory of cognitive development, the use of concrete learning media is considered effective in strengthening the understanding of basic mathematical concepts among children with special needs. Through a contextual learning approach that integrates visual, tactile, and logical elements, puzzles facilitate the development of number recognition skills through visual and manipulative learning activities(Ismail, St.Hajar, Said, & Mustafa, 2025).

Puzzles are interactive learning tools that encourage patience and persistence while assembling image pieces, and are effective in enhancing preschool children's cognitive development. Puzzle play therapy is one of the interactive therapeutic media

for children that helps strengthen and stimulate their muscles by assembling pieces of images into a complete and visually appealing form. Puzzle play requires patience and persistence in arranging picture or number pieces. In general, puzzles are made of thin layers consisting of 2–3 sheets or even 4–6 sheets, commonly produced from wood or cardboard(Utami, Rashid, & Sansuwito, 2024).

Puzzle games for children have an impact on improving short-term memory. Through puzzle play, children can train accuracy and hand–eye coordination, enhance fine motor skills(Khoirunisa & Widadi, 2024), and optimize the functions of both the right and left hemispheres of the brain. According to Panzilion et al. (2020), brain teaser and puzzle interventions influence the development of fine and gross motor skills in children because these activities coordinate hand and foot movements and improve balance between motor function and vision, enabling children to develop optimally(Utami et al., 2024).

The child initially experienced difficulty manipulating small objects, such as grasping a pencil or stacking small items. Following the therapy, improvements in hand–eye coordination were observed, and the child was able to handle puzzle pieces more effectively(Khoirunisa & Widadi, 2024). Research conducted by Safira in 2021 found that puzzle therapy significantly improves fine motor development in preschool children at RT 16, Inkopad Complex, Bogor. Among 30 participants, statistical analysis showed a significant effect ($p = 0.023$), indicating that puzzle play positively influences fine motor skills. These findings are consistent with previous studies reporting significant results ($p < 0.05$), supporting the effectiveness of puzzle therapy in early childhood development. Fine motor skills increased after receiving the puzzle play therapy intervention. Children's fine motor development does not progress, it can cause difficulties in performing quick and precise movements. Puzzles, which include images, shapes, and colors, help improve hand–eye coordination and support logical thinking skills(Safira, 2023).

Research Mandala et al in 2022 revealed that game-based learning media using puzzles and quizzes were able to increase students' learning motivation by up to 98.7%. Another study by Yustantia and Marwan (2023) showed that the use of puzzle-based media in accounting education was highly effective in enhancing student engagement and improving their understanding of the subject matter. These findings support the notion that puzzle-based game learning media have substantial potential for application across various levels of education(Pratama et al., 2025).

Playing puzzles helps children improve and develop their overall personality in a holistic manner, encompassing moral, physical, intellectual, emotional, and social aspects, while also encouraging children to learn and play in a comfortable and enjoyable way. The ability to recognize colors is essential for brain development, as color recognition can stimulate visual sensitivity when an object's colors are exposed to direct sunlight. Understanding the concept of size is a mathematical ability in children that involves describing object characteristics based on height (tall–short), length (long–short), quantity (many–few), and weight (heavy–light)(Ekayuti, 2023).

Puzzles designed for children with special needs like down syndrome should feature appropriate sizes, a limited number of pieces, and shapes that are easy to grasp and recognize. The recommended number of pieces ranges from 4 to 12, with curved forms that support ease of handling and identification. The use of bright, contrasting colors is advised, while avoiding similar color tones to facilitate piece

differentiation, as children with Down syndrome generally prefer vivid colors. Engagement in puzzle play has been shown to enhance concentration, promote problem-solving skills, and strengthen hand eye coordination. Additionally, puzzles support the development of visual perception by enabling children to recognize and differentiate colors, shapes, and sizes of puzzle components(Mufidah, Kurniawati, & Anisah, 2025)

Square-shaped pieces are arranged to form a rectangular image. Since all the pieces are identically square, their pictorial content becomes the only source of information available for reconstruction. Puzzle-solving methods have developed rapidly over the past decade, and although they cannot guarantee optimal solutions, contemporary methods exist to solve them. Global convex polygonal shapes (for apictorial puzzles) or convex polygonal images (for pictorial puzzles) are cut by multiple straight lines at arbitrary positions and directions, thereby dividing the puzzle shape into many convex polygonal fragments(Harel et al., 2024).

The designer of the “puzzle” game uses typographic elements in the design process to achieve visual communication goals by combining color and shape with letters or text tailored to the child’s age group, using a formal simulation method that is acceptable and aligned with the learning context. Each visual text has its own design theme corresponding to the meaning of the text, including elements that distinguish it from other texts in terms of form and content, as well as the strength and aesthetic quality of its composing elements such as headline, text writing The geometric design uses white to highlight numbers and letters. This color contrast helps children distinguish between the background color of the shapes and the printed numbers, while also training their visual memory(Abdel et al., 2024).

Color is one of the most important sources of attraction in capturing the viewer’s visual attention through contrast and harmony. Designers working in the field of educational puzzle game design must carefully select appropriate colors, as color plays a crucial role in puzzle game design. This is due to the effectiveness of color in conveying ideas and enhancing visual appeal. Strong color usage can help resolve design challenges. Color is sometimes used to clarify spatial forms and to provide a sense of scale, dimension, volume, and depth through its psychological and physiological effects, in addition to the aesthetic value created by the diversity of color relationships. The use of color in puzzle design therefore requires objective and systematic arrangement(Abdel et al., 2024).

Conclusions And Recommendation

Conclusion

Inclusive puzzle design is an innovative STEM-based learning tool that effectively supports the cognitive, sensory, and motor development of children with special needs. By applying inclusive design principles and Gestalt theory, puzzle-based learning helps children recognize patterns, understand shapes holistically, and engage in problem-solving activities. Additionally, puzzles promote active participation, motivation, and meaningful interaction with teachers and caregivers. Overall, inclusive puzzle design offers a practical and adaptable approach to creating equitable and engaging STEM learning experiences for children with special needs.

Recommendation

This study has several limitations. Recommendation for future research are sample size and the use of a single educational context limit the generalizability of the findings. Second, the study only examined the short-term effects of using puzzles as a learning medium; therefore, the long-term impact on children's cognitive development and STEM-related skills remains unclear. Third, individual differences in children's abilities, the level of support provided by teachers or parents, and prior experience with puzzle-based learning may have influenced the results and explore the use of digital or technology-based puzzles.

References

Abdel, B., Fathi, N., & Mohammad, N. J. (2024). Techniques for Designing Puzzle Shapes and their Role in Children ' s Learning. *International Journal of Religion*, *3538*(8), 839–849.

Ade, R. (2025). Metode Penelitian dan Pengembangan (R&D) : Pengertian, Jenis dan Tahapan. *DIAJAR: Jurnal Pendidikan Dan Pembelajaran*, *4*(3), 459–470. https://doi.org/10.54259/diajar.v4i3.5092

Biidnillah, P., & Wahyuni, A. T. (2025). Terapi Bermain Puzzle untuk Meningkatkan Konsentrasi Belajar Anak Berkebutuhan Khusus di SLB Dharma Putra Kalipucang Edu Happiness : *Edu Happiness Jurnal Ilmiah Perkembangan Anak Usia Dini*, *04*(2), 136–146. https://doi.org/https://doi.org/10.62515/jos

Bustamante-mora, A., Diéguez-rebolledo, M., Díaz-arancibia, J., Sánchez-vázquez, E., & Medina-gómez, J. (2025). Inclusive Pedagogical Models in STEM : The Importance of Emotional Intelligence , Resilience , and Motivation with a Gender Perspective. *Sustainability*, *17*(4437), 1–39. https://doi.org/https://doi.org/10.3390/su17104437

Castaneda, J. A. C., Lin, P. C., Hung, P. C. K., Zhong, H. X., Tseng, H. A., Huang, Y. F., & Ahmad, R. (2025). Designing inclusive tech playful educative solutions for visually impaired learners in STEM education. *Smart Learning Environments*. https://doi.org/10.1186/s40561-024-00358-x

Eason, S. H., Hurst, M. A., Kerr, K., Claessens, A., & Levine, S. C. (2022). Enhancing parent and child shape talk during puzzle play ☆. *Cognitive Development*, *64*(September), 101250. https://doi.org/10.1016/j.cogdev.2022.101250

Ekayuti, I. D. (2023). Mengembangkan Kemampuan Mengenal Bentuk, Warna Dan Ukuran Menggunakan Model Problem Based Learning Dan Media Puzzle Shape Pada Anak Usia 4-5 Tahun. *Maimunah*, *3*(3), 20–31. Retrieved from https://ppjp.ulm.ac.id/journals/index.php/jikad

Fadhil, I., Masyitah, & Mahmudi. (2025). Model Pembelajaran Berbasis Game Dalam Pendidikan Jasmani Inklusif Bagi Siswa Berkebutuhan Khusus. *Gelanggang Olahraga: Jurnal Pendidikan Jasmani Dan Olahraga*, *9*(1), 119–126. https://doi.org/10.31539/35cr1861

Hamidaturrohmah, Muh, M., Aniatus, S., & Nailufar Daniela Arnesti Nailufar. (2023). Pengembangan Buku Suplemen Intervensi Life Skill Berbasis STEAM Bagi Anak Berkebutuhan Khusus di Sekolah Dasar Inklusi. *Indonesian Journal of Humanities and Social Sciences*, *4*(3), 609–622. Retrieved from https://ejournal.uit-lirboyo.ac.id/index.php/IJHSS

Harel, P., Itzhak, O., & Ohad, S. (2024). Pictorial and Apictorial Polygonal Jigsaw Puzzles from Arbitrary Number of Crossing Cuts. *International Journal of Computer Vision*, *132*(9), 3428–3462. https://doi.org/10.1007/s11263-024-02033-7

Ismail, W. A. S., St.Hajar, Said, A., & Mustafa. (2025). Terapi Permainan Puzzle Terhadap Kemampuan. *Edustudent: Jurnal Ilmiah Pendidikan Dan Pengembangan Pembelajaran*, *4*(3), 88–91. https://doi.org/https://doi.org/10.26858/edustudent.v4i3.72807

Khoirunisa, N. Z., & Widadi, S. Y. (2024). Nursing Care Analysis in Children with Down Syndrome and the Application of Puzzle Play Therapy. *Nursing Case Insight Journal*, *2*(3), 83–86. Retrieved from https://nci.journalhealth.org/index.php/nci

Monteira, S. F. (2025). Creative Approaches for Inclusive STEM Learning in Early Years. *Early Childhood Education Journal*, (April). https://doi.org/10.1007/s10643-025-01922-x

Mufidah, Z. M., Kurniawati, R., & Anisah, R. L. (2025). Puzzle Stimulation Therapy For Developmental. *Journal of Public Health and Nursing (JPHN)*, *1*(1), 29–34. Retrieved from https://journal.abhinaya.co.id/index.php/jphn

Munawwa, M. H., Yusuf, M., & Rejeki, D. S. (1999). Puzzle-Based Learning To Enhance Body Parts Knowledge In Second-Grade Students With Intellectual Disabilities At Slb Negeri Karanganyar, *4*(2), 58–64.

Pratama, V. F., Annisa, I. F., Teknik, F., Nahdlatul, U., & Sumatera, U. (2025). TOFEDU : The Future of Education Journal Designing a Puzzle Game for Delivering the Interactive Learning Material at SMP Kartika 1-7 Padang. *TOFEDU: The Future of Education Journal*, *4*(1), 198–206. Retrieved from https://journal.tofedu.or.id/index.php/journal/index%0A

Safira, N. (2023). The Effect of Puzzle Playing Therapy on Fine Motor Development in Preschool Children. *Journal Of Complementary Nursing*, *2*(1). https://doi.org/10.53801/jcn.v2i1.61

Sulistia, Ermawati, G. N., Fadhila, M., Zidan, M. P. N., & Siti, F. (2022). Pembuatan Dan Penerapan Mainan Edukasi (Puzzle) Untuk Stimulasi Kognitif Anak Berkebutuhan Khusus Di RSUD Ulin Banjarmasin. *PUSAKO : Jurnal Pengabdian Psikologi*, *01*(02), 46–54.

Utami, W., Rashid, N. A., & Sansuwito, T. (2024). The Effectiveness of Educational Puzzle on the Cognitive Ability of Stunting Children at the Age of Preschool : Literature Review. *Malaysian Journal of Medicine and Health Sciences*, *20*(4), 195–199.

Wahyuni, T. S. A. S. H. (2018). Stimulasi Permainan Puzzle Berpengaruh Terhadap Perkembangan Sosial Dan Kemandirian Anak Usia Prasekolah. *Jurnal Keperawatan Silampari*, *1*(2), 62–77. https://doi.org/https://doi.org/10.31539/jks.v1i2.9

Yorde, S., & Mccollum, J. A. (2018). A Workable Problem : Constructing a 3-D Puzzle With Young Children With Disabilities A Workable Problem : Constructing a 3-D Puzzle With Young Children With Disabilities. *Journal of Research in Childhood Education*, *32*(3), 326–342. https://doi.org/10.1080/02568543.2018.1465498